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**PREPARATION OF DETECTOR PAPER CONTAINING
ORASOL NAVY BLUE 2RB**

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ABSTRACT

Orasol Navy Blue 2RB was selected as a dyestuff to be used in paper for detecting propylene glycol, a possible ingredient of liquids for chemical warfare training. Dyestuff as received from the manufacturer contained a large proportion of particles that were too fine to be used in making paper. These fines were successfully removed by settling or were agglomerated by spray-drying. For propylene glycol detection, the base paper should be prepared without internal sizing but sized papers were also prepared for possible use with other liquids. Paper basis weight was reduced about 20% from the usual weight for Canadian detector papers without any decrease in performance except in wet strength of unsized paper. The effects of glass fiber, titanium dioxide pigment and background color were investigated.

RÉSUMÉ

On sélectionna le Bleu marin Orasol 2RB comme matière colorante entrant dans la fabrication du papier détecteur de propylène glycol; ce dernier étant un ingrédient d'un liquide utilisé lors de période d'entraînement à la guerre chimique. Les matières colorantes reçues du fabriquant contenaient une grande proportion de particules fines pour être utilisées dans la fabrication du papier détecteur. Ces particules fines furent retirées avec succès, soit par déposition, ou soit par agglomération par séchage au pulvérisateur. Pour la détection du propylène glycol, le papier de base devrait être préparé sans aucun apprêt; par contre, du papier fabriqué à partir d'une pâte contenant un apprêt fut préparé pour utilisation possible avec d'autres liquides. Le poids par unité de surface du papier a pu être réduit d'environ 20% de celui du papier détecteur canadien sans toutefois en réduire les qualités physiques, exception faite de la résistance à la rupture du papier sans apprêt, mouillé. Les effets des fibres de verre, des pigments de dioxyde de titane et de la couleur de fond furent aussi étudiés.

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INTRODUCTION

Orasol Navy Blue 2RB (ONB) was first evaluated at DREO as a possible dyestuff for detector paper during development of a paper for detecting training liquids. At that time, Eastman Fast Blue B-GLF was selected for the training paper in preference to ONB because ONB responded to glycol antifreeze and Fast Blue B-GLF responded to it only very slowly. Antifreeze was considered to be a possible contaminant in the field and response to it was undesirable. When there was a need for a training paper to respond to propylene glycol, Orasol Navy Blue was selected. Besides responding to the desired compound it was known to have the necessary properties for paper production; i.e. it was water insoluble, heat resistant and was unaffected by papermaking chemicals.

Operational detector papers (1,2) and the Canadian training paper were made with an internal sizing agent such as wood rosin or modified wood rosin so as to reduce the rate of water absorption and the amount of water absorbed. Because of the hydrophilic nature of propylene glycol, its rate of absorption would be expected to be reduced by rosin size. It was therefore necessary to consider using an unsized paper. For a training paper, lack of water repellency probably would not be serious especially since a wet-strength resin would be used to confer considerable strength to the paper even when wet.

This report describes some of the work at DREO on the preparation of detector papers, both sized and unsized, containing Orasol Navy Blue 2RB. Exploratory studies were carried out by preparing handsheets on an 8-inch square handsheet mould and then selected formulas and procedures were evaluated by preparing paper on the DREO experimental paper machine (3). All papers were prepared by adding a suspension of ONB to paper making stock before forming the paper.

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DYE PREPARATION

Like most dyestuffs for detecting liquid CW agents and training agents, Orasol Navy Blue functions by being dissolved in drops of the liquid to be detected thereby staining the white cellulose fibers of the paper. There is no chemical reaction producing a color change. If the dyestuff contains large particles or large agglomerates they will appear in the paper as dark spots making it difficult to detect small drops of liquids. Also large particles, particularly agglomerates, tend to smear when rubbed. If the particles are too small they increase the background color of the paper decreasing the contrast between paper and colored spot.

It had been found with other dyes and substantiated with ONB that screening through 325 mesh (44- μ m opening) removed particles that were too large. Fine particles cannot be removed completely from a dyestuff powder but allowable limits can be established for detector papers. For 3-way paper for example the specified limits (2,4) were

A2	40% by weight finer than 10 μ m
E	32% by weight finer than 10 μ m
EDA	32% by weight finer than 10 μ m

and for the Eastman Fast Blue B-GLF for training paper the limit was the same as for E and EDA.

Orasol Navy Blue 2RB as purchased from Ciba-Geigy contained a large proportion of material that was too fine as well as some that was too coarse. Coarse particles were removed by screening a water suspension through a 325 mesh screen in a 18-inch vibrating separator. Wet screening was used because of the difficulties in screening fine, light, dry powders and in order to reduce dusting. With a screen as fine as 325 mesh it was necessary to use a spray of water to wash particles through the screen. This resulted in screen filtrates that were quite dilute. Dye that did not pass the screen was hammer milled (wet) and then returned to the screen. Hammer milling was usually repeated several times until the amount of oversize was acceptably small.

Gravity settling was then used to concentrate screen filtrate and to separate it into a product fraction (sediment) and a fines fraction (decantate). Table I gives data for screening and sedimentation of three batches of a single dye shipment. Amount of oversize was determined by drying the wet "cake" from the screen; solids concentrations of decantate and sediment were determined by evaporating samples to dryness. Oversize fractions were retained and recycled to a subsequent screening. Dye

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TABLE I
Preparation of Dyes Using Sedimentation

	Weight (g)	Concentration (%)	Dye Number*	Spray-Dried Product Number
1. Start	450	100	266	
Oversize	66	100		
Decantate	192	0.55	281	
Product	156	6.68	280	
Loss	36	-		
2. Start	1427	100	266	
Oversize	112	100		
Decantate	691	1.22	291	
Product	685	22.12	292	320
Loss	-19	-		
3. Start	1361	100	266	
Oversize	222	100		
Decantate	564	0.604	297	315
Product	539	25.73	296	
Loss	36	-		

* DREO code number to identify the dye fraction.

particles in the decantates were too fine to use and were discarded. In all three trials the amount of dye in the decantate was greater than in the product fractions.

Air drying product fractions resulted in hard cakes which were impossible to properly redisperse in water. Either lumps were left undispersed or if mechanical means were used to break them up there was the risk of producing additional fines. One method used to overcome this problem with Eastman Fast Blue B-GLF was to add to the slurry a suspension of an equal quantity of diatomaceous earth. The mixture was filtered as quickly as possible to prevent separation and then dried. This procedure gave powders that were readily dispersed in water.

As a means of preparing water-dispersible products without a diluent powder, spray drying (5) of suspensions of Orasol Navy Blue was investigated. A laboratory spray dryer 3 ft in diameter gave promising results with product fraction No. 292 (Table I). Since good results were also obtained with a decantate (No. 297), it was decided to eliminate the gravity settling operation and proceed directly to spray drying of filtrate from the screen.

Table II gives data for two screening trials to produce filtrates for investigating spray drying. A description of the spray drying work with Orasol Navy Blue and other dyes is planned for a future report. The present report presents only the results for the four dried fractions used to prepare detector papers containing Orasol Navy Blue.

TABLE II

Preparation of Spray-Dried Dyes Without Sedimentation

	Weight (g)	Concentration (%)	Dye Number	Spray-Dried Product Number
1. Start	907	100		
Oversize	101	100		
Filtrate	752	0.776	351-352	361
Loss	54	-		
2. Start	737	100		
Oversize	120	100		
Filtrate	648	0.86	439	440
Loss	-31	-		

Particle size distributions were measured by gravity sedimentation in water (6) using first a Gallenkamp sedimentation balance and later a Cahn sedimentation apparatus. Both of these systems measure the weight of accumulated sediment and relate it to diameter calculated by Stoke's equation. The Gallenkamp apparatus had a torsion balance from which readings had to be observed and recorded by an operator. With the Cahn apparatus there was an

electronic balance with an output to a recorder.

Particle-size data for dye suspensions and spray-dried products are given in Table III. Only one dye, No. 320, was measured with both balances. There was good agreement at the large-particle end of the distribution but not at the fine-particle end. Particle-size distribution of decantates was not measured so there is no information on the change in size distribution effected by spray drying decantate No. 297 (Table I). However, there must have been considerable agglomeration because the spray-dried product (No. 315) was reasonably free of fines and was suitable for use in preparing paper. When screen filtrate No. 439 (Table II) was spray dried, average particle size was increased from 6.6 to 16.5 μm and amount of fines was reduced from 54% to 14%. Note that in this report fines are given as weight percent less than 8 μm whereas previously 10 μm was used.

TABLE III
Particle Size Data for Dye Products

Dye Number	Form	Mass Median Diameter (μm)	Weight Percent Less than		Balance Used
			8 μm	25 μm	
280	Sediment Slurry	10.2	41	93	Gallenkamp
292	Sediment Slurry	12.1	34	93	Gallenkamp
296	Sediment Slurry	14.1	31	81	Gallenkamp
315	Spray Dried No. 297	8.4	46	~100	Gallenkamp
320	Spray Dried No. 292	13.7	27	89	Gallenkamp
320	Spray Dried No. 292	15.7	19	90	Cahn
361	Spray Dried No. 351	7.6	53	~100	Gallenkamp
439	Screen Filtrate	6.6	54	85	Cahn
440	Spray Dried No. 439	16.5	14	72	Cahn
441	Mixed Spray Dried	15.6	18	77	Cahn

BASE PAPER

The base paper used for Orasol Navy Blue was the same as for 3-way detector paper with minor modifications. According to the specification for 3-way paper (2) a bleached sulfate pulp should be used although bleached sulfite is acceptable. After beating or refining, rosin size, alum and melamine-formaldehyde wet-strength resin are to be added followed by dyestuffs.

Basis weight of the paper is to be 80 g/m². Dry and wet tensile strength were specified and the amount of water absorbed (Cobb test) but the principle test for determining suitability for liquid agent detection other than color response tests was a test to measure absorption time of organic liquids. In this test, drops of methyl salicylate 3 mm in diameter (0.015 ml) were placed on the paper and the time for surface moisture to disappear was measured. The time was to be not less than 12 seconds nor more than 45 seconds. With the same size drop of ethylene glycol monomethyl ether (methyl cellosolve) the time was to be not less than 8 nor more than 30 seconds. If the time is too short liquid drops are absorbed before they have had time to spread and if too long, development of full color can be delayed. A similar test was carried out with propylene glycol using a drop diameter of 2.35 mm (0.0068 ml).

Spread factor was also measured by applying drops of methyl salicylate 1.5 mm in diameter and measuring the diameter of the fully developed spots. Spread factor is the ratio of spot diameter to drop diameter.

Data are given in Table IV to compare the absorption properties of different pulps beaten to different freeness levels. The pulps used were obtained from Canadian International Pulp Sales Limited, Montreal. The sulfate pulp (Cellate) was a bleached, softwood sulfate pulp manufactured at La Tuque, Quebec. The sulfite was a chlorine dioxide bleached pulp made from eastern Canadian softwood. The hardwood pulp (Supercell AO-2) was made from southeastern United States hardwood. The pulps were beaten in a 1½-lb laboratory beater (3) to the freeness shown, furnished with rosin size (Dry X Rosin Size, Hercules Canada Limited) wet strength resin (Parex 607, Cyanamid of Canada, Inc.) and alum. Handsheets were formed using an 8-inch square handsheet mould. White water was recycled and the first six sheets were discarded.

The results in Table IV show that as beating proceeded absorption time increased and with the softwood pulps the times were high compared to the specified upper limits of 45 for methyl salicylate and 30 for methyl cellosolve. Absorption times were much lower for the hardwood pulp. Water absorption (Cobb test) and spread factor were not appreciably affected by pulp or extent of beating. Reducing basis weight from 80 g/m² to 60 g/m² had very little effect; absorption times were increased slightly, water absorption was reduced slightly and spread factor increased only from 9.8 to 10.6.

Although test results are not given in Table IV, strength properties followed the expected trends. Beating increased tensile strength and burst and decreased tear strength. The sulfate pulp was the strongest, the hardwood pulp the weakest, especially wet strength. Tensile strength was approximately proportional to basis weight.

In order to make it easier to meet both strength and absorption requirements of the 3-way paper specification, a mixture of 80% sulfate and 20% hardwood could be used as a standard base for detector papers. For 3-way detector paper a Canadian standard freeness (CSF) of 550 ml and a paper basis weight of 80 g/m² would still be recommended but for Orasol Navy Blue papers a CSF of 500 ml and a weight of 65 g/m² were generally used. In commercial production, reducing the weight of paper would allow a

TABLE IV

Effect of Type of Pulp and Extent of Beating
on Absorption Characteristics of Laboratory Handsheets

Pulp	Canadian Standard Freeness (ml)	Basis Weight (g/m ²)	Density (kg/m ³)	Absorption Time (s)		Cobb Test (g/m ²)	Spread Factor
				MeSal*	MeCel*		
Sulfate	600	80	564	34	22	18.2	9.8
	550		587	59	30	18.5	9.8
	500		606	131	53	18.8	9.7
	450		642	165	86	19.7	9.7
	600	60	545	33	26	17.7	10.7
	550		564	79	38	17.2	10.4
	500		584	140	63	17.7	10.6
	450		607	180	83	18.4	10.5
Sulfite	550	60	544	47	24	16.8	9.5
	500		586	69	43	15.7	9.3
	450		601	114	54	17.2	9.4
Hardwood	550	60	499	21	15	18.6	9.6
	500		493	25	15	17.4	10.0
	450		502	30	20	17.7	9.2
Sulfate 80/ Hardwood 20	550	80	567	39	32	18.2	
	500	60	550	45	31	17.8	

* Methyl salicylate and methyl cellosolve

corresponding increase in the area of paper produced for the same weight of dyestuff. This reduction in cost would be justified provided there was no decrease in detection performance.

Some typical results for both sized and unsized laboratory hand-sheets are given in Table V. Propylene glycol was absorbed much more slowly than either methyl salicylate or methyl cellosolve even by unsized papers. With either Dry X rosin size or Neuphor 100 (Hercules Canada Limited) the absorption time was much greater. Adding titanium dioxide pigment (Titanox A-WD, Canadian Titanium Pigments Ltd.) had very little effect on these properties but one-micron glass fiber (Code 108, Johns-Manville Canada Inc.) reduced absorption times considerably.

TABLE V

Typical Results for Laboratory Papers
Softwood/Hardwood = 80/20, (CSF = 500 ml, Basis Weight = 65 g/m²)

Internal Sizing Agent	Additive	Density (kg/m ³)	Absorption Time (s)			Cobb Test (g/m ²)
			Mesal	MeCel	PG*	
None	None	578	34		129	-
"	TiO ₂	578	34		126	
"	Glass Fiber	525	13		54	
"	Both	521	16	14	67	
Neuphor 100	None	554	39	32	338	17.9
Rosin	None	559	31	29	246	20.9
Rosin	Glass Fiber	499	11	11	75	18.2

* Propylene glycol.

Glass fiber was added to determine what effect it would have on retention of dyestuff and on other properties of the paper. While glass fiber is expensive compared to wood pulp, it could be used if it allowed a sufficiently large reduction in the amount of dye that had to be added to obtain a desired level in the paper product. Titanium dioxide was added to try to increase the contrast between background and colored spot. However, it seemed to decrease the speed of response to propylene glycol and to decrease dyestuff retention without any apparent effect on color contrast, so its use was discontinued.

It should be pointed out that different bales of the same grade of pulp gave different results so while the results in Tables IV and V indicate trends the actual values are not strictly reproducible.

DETECTOR PAPER

Table VI gives data for papers containing Orasol Navy Blue that were prepared on the DREO experimental paper machine (3). The specific formulas and dye loading used were selected on the basis of examination of laboratory handsheets. The papers were made over a period of 3½ years using five different bales of softwood pulp and two different bales of hardwood pulp. Machine operating conditions were essentially the same throughout the period but there were a number of minor changes. For example the "wire" was changed from a bronze screen to one of polyester with approximately the same drainage rate. Colors of the papers are illustrated in Figure 1 which was made from actual pieces of the papers.

For the runs with 5% glass fiber added to the stock, retention of dyestuff in the paper increased as particle size increased. There were inconsistencies and the data were scattered but the slope of the linear regression line was significant at the 98% level. The runs without glass fiber showed the same general trend but the slope was not significant. Retention with glass fiber was slightly higher than without it. A series of papers prepared under more uniform conditions might have given a more definite relationship between particle size and retention.

It should be noted that in Table VI the dye loading is a nominal loading expressed as a percentage of wood pulp. Dye content of paper was determined analytically and is given as a percentage of the final paper on a dry basis. Retention was calculated from paper content and actual loading expressed as a percentage of total solids added to the stock. The calculation assumes complete retention of paper fiber and non-fiber solids which is not strictly correct.

Background color of paper (Figure 1) was not directly related to particle diameter nor to weight percent less than 8 µm. Numbers 164, 166, 165 and 190 were prepared with dyes with relatively large mass median diameter but the color, even at much lower dye content, was darker than Runs 220 and 240 which were prepared with dyes of smaller median diameter. The difference is that the lighter colored papers were prepared with spray-dried dyes. Background color depends upon very small particles which were removed or agglomerated during spray drying. With gravity settling, the proportion of these very small particles cannot be measured. However, the particle-size distribution curves of the dyes indicated that spray-dried products would have a much smaller content of particles below about 4 µm than dyes that were not spray dried. Spray drying therefore not only enabled an appreciable portion of the Orasol Navy Blue to be recovered and used that would otherwise have to be discarded but also gave papers that had a lighter

TABLE VI

Papers Prepared with Orasol Navy Blue 2RB
(Papers were 80/20 mixture of softwood and hardwood, unsized, basis weight of 65 g/m²)

Run No.	Glass Fiber (% of Pulp)	Dyestuff Used			Nominal Load (% Pulp)	Dyestuff in Paper		Background Color Added Color*	% Pulp
		No. No.	Particle Size			Content (%)	Retention (%)		
			mmd (µm)	wt % ($<8\text{ }\mu\text{m}$)					
164	0	280	10.2	41	0.5	0.35	71		
166	5	"				0.42	84		
165	10	"				0.40	82		
190A	5	296	14.1	31	1.2	0.83	78		
B	5	"			1.8	1.26	80	CYP	1.0
210B	5	315	8.4	46	1.5	1.02	75		
C	5	"			2.0	1.41	80	YO	0.4
209B	5	320	15.7	19	1.5	1.30	94		
C	5	"			2.0	1.64	90	YO	1.0
220B	5	361	7.6	53	1.5				
C	5	"			2.0			YO	0.4
240G1	5	361	7.6	53	1.00	0.69	75		
G2	5	"			1.33	0.88	73	YO	0.4
G3	5	"			1.78			YO	1.0
249S1	0	361	7.6	53	1.00	0.64	69		
S2	0	"			1.33	0.94	77	YO	0.4
S3	0	"			1.78	1.26	78	YO	1.0
249B	0	441	15.6	18	1.25	0.97	85		
247**	0	"			1.20	0.76	67		

* CYP = Chrome yellow pigment

YO = Yellow Ochre pigment

** Sized with Neuphor 100.

background color. Another advantage is that spray drying allows the dye to be prepared as a water-dispersible powder without having to add a material such as diatomaceous earth.

In order to neutralize the blue background color of the paper Chrome Yellow Pigment (CYP) and then Yellow Ochre (YO) were added. CYP gave a greenish color for Run 190B instead of a neutral grey. With Yellow Ochre a grey color was obtained for some of the papers, for example, Run 220C. Runs 240G2 and 240S2 had too much YO for the amount of blue color. By adjusting the amount of YO pigment it would be possible to obtain a neutral grey color or a sand color, if this were desired.

Small drops of simulant were applied to papers of different color and it was concluded that drops on the colored backgrounds were not appreciably easier to detect than on a blue background. Consequently, added color was not used for the last two runs of Table VI.

Absorption times of machine-made papers are given in Table VII. Instead of presenting results for individual runs, the data were averaged for each additive combination. As noted earlier for handsheet data, the addition of glass fiber reduced absorption time considerably. It also reduced the density of the paper. Adding 1.0% Neuphor 100 increased absorption time of propylene glycol by about three times.

TABLE VII

Effect of Additives on Absorption Properties of Paper

Number of Runs	Glass Fiber (% of Pulp)	Neuphor 100 (% of Pulp)	Basis Weight (g/m ²)	Density (kg/m ³)	Absorption Time (s)			Water Absorption (g/m ²)
					MeSal	MeCel	PG	
7	0	0	65	540	31		148	
6	5	0	65	515	23		98	
1	10	0	65	482	12		67	
7	0	1.0	65	535	36	29	443	18.4
2	0	1.5	65	538	34	30		16.5
1	0	2.0	65	531	33	33		14.3
4	0	1.5	80	537	22	21		19.9
1	5	1.5	65	499	23	16	276	18.6

Tensile and bursting strength data in Table VIII indicate that glass fiber reduced the strength, particularly wet strength. Adding the sizing agent Neuphor 100 increased the wet strength considerably. For laboratory handsheets prepared under more consistent conditions than the machine papers, the addition of either Neuphor or rosin size reduced dry strength by about 10% and increased wet strength by up to 70%. In order to meet the specification requirements for tensile strength, a paper with a

basis weight of 65 g/m² would have to have a dry breaking length of 5500 m in the machine direction and a wet breaking length of 1650 m. Since a lower cross-direction strength is permitted, averages as given in Table VIII could be somewhat lower than these values. Thus papers without glass would meet specification values but the two with glass would not.

TABLE VIII

Effect of Glass Fiber and Sizing on Strength
Properties of Detector Paper

Number of Runs	Glass Fiber (% of Pulp)	Neuphor 100 (% of Pulp)	Breaking Length (m) (Av. of Both Directions)			Burst Index kPa.m ² g
			Dry	Wet	$\frac{\text{Wet}}{\text{Dry}}$	
5	0	0	6760	1620	0.238	4.2
4	5	0	6500	1280	0.196	3.9
1	10	0	6450	1160	0.193	2.6
5	0	1.0	7030	2510	0.357	4.2
2	0	1.5	6940	2640	0.398	4.4
1	0	2.0	7080	2830	0.401	4.8

COLOR RESPONSE OF DETECTOR PAPER

Quantitative data on the response of ONB Detector Paper to propylene glycol are given in Table IX. The papers used were machine papers without glass or added color. Drops were prepared by using two concentric hypodermic needles and stripping drops from the inner needle by a flow of air in the annular space between them. The liquid flow rate was measured by weighing liquid collected over a given time and the rate of drop formation was determined by collecting drops on detector paper. Drop size was calculated from these two measurements. Small drops were absorbed very quickly but larger ones produced color a little faster. Finally, unsized papers absorbed propylene glycol more quickly, produced color in a shorter time and gave greater spread factors than sized papers.

Both sized and unsized papers with ONB responded to tributyl phosphate and DMMPA (dimethylmorpholinophosphoramidate) in about one second and to diethyl phthalate in 6-10 s.

TABLE IX

Effect of Sizing on the Response of Paper
to Drops of Propylene Glycol

Paper	Not Sized			Sized 1% Neuphor 100		
Drop Diameter (mm)	0.38	0.57	1.12	0.38	0.57	1.12
Absorption Time (s)	< 1	5.1	30	< 1	7.8	48
Time to Color (s)	10.8	7.5	8.8	12.3	10.5	11.3
Spot Diameter (mm)	1.9	3.5	8.8	1.6	3.2	8.0
Spread Factor	5.1	6.1	7.8	4.3	5.7	7.1

The intensity of color developed by a range of chemicals and chemical products is given in Table X. The chemical products tested were mainly wetting and dispersing agents because these must be used in dispersing the powder in water before screening, before spray drying or when redispersing spray-dried products. While a wetting agent that produced no color would have an advantage it was found with ONB and with other dyes as well that wetting agents that produced no color generally were not effective in dispersing particles. Santomerse 85B (Monsanto) and sodium lauryl sulfate produced only a slight color on detector paper yet were effective wetting agents. When the latter was added before spray drying the products generally dispersed readily in water without additional wetting agent.

CONCLUSIONS

1. Orasol Navy Blue 2RB was selected for preparing papers for detecting drops of propylene glycol.
2. The large proportion of particles too fine for preparing detector paper was removed by gravity settling in water or the particles were agglomerated by spray drying.
3. Spray drying not only eliminated the problem of fine particles but gave a dry powder that was readily dispersed in water.

TABLE X

Response of Sized Paper to Various Liquids

A. No Color

- carbon tetrachloride
- perchloroethylene
- pentane
- cyclohexane
- heptane
- Dow Corning Antifoam C
- Tamol 731 (5%)
- Aerosol OT (1%)
- styrene-maleic anhydride 1440H (10%)
- Ahcowet SDS (5%)
- ammonium hydroxide
- hydrochloric acid (3N)
- sulfuric acid (1N)
- potassium chloride

B. Slight Color

- xylene
- Dow Corning Antifoam H-10
- Santomerse 85B (5%)
- sodium lauryl sulfate (5%)

C. Light Color

- trichloroethylene
- benzene
- toluene
- Triton X-100 (5%)

D. Medium Color

- methylene chloride
- 1,3-dichloropropane
- Triton X-102 (5%)
- Deceresol NI (5%)

TABLE X (Continued)

E. Dark Color

- diethyl phthalate
- trioctyl phosphate
- tributyl phosphate
- DMMPA
- methyl salicylate
- butyl acetate
- dimethyl sulfoxide
- methanol
- ethanol
- iso-propanol
- n-butanol
- n-octanol
- ethylene glycol
- triethylene glycol
- polyethylene glycol 200
- propylene glycol
- acetone
- methyl ethyl ketone
- dioxane-1,4
- acetic acid
- antifreeze

4. Leaving out internal sizing agents increased the rate of absorption of propylene glycol with some reduction in wet tensile strength.
5. Basis weight was reduced from 80 g/m² to 65 g/m² without a reduction in detection capability. Tensile strength was still sufficient to meet the requirements for paper of basis weight 80 g/m². Increased beating or refining to a lower freeness value is recommended for the lower basis weight.
6. The addition of titanium dioxide pigment gave a whiter background but did not increase the ease of detection of liquid drops.
7. Papers with a neutral background color were prepared by adding a small amount of a Yellow Ochre pigment. As with titanium dioxide there was no apparent improvement in the detection of small drops.
8. The addition of 5% of glass fibre about 1 µm in diameter appreciably increased the rate of absorption of organic liquids including propylene glycol and reduced the tensile strength, particularly wet strength. Dyestuff retention was increased slightly.

ACKNOWLEDGEMENT

Most of the work on dye preparation, spray drying and preparation of handsheets was carried out by D.A. MacLeod.

REFERENCES

- 1,3-dichloropropane
 - Triton X-102 (5%)
 - Deceresol NI (5%)
2. Canadian Forces Specification CF-P-214A: Paper, Chemical Agent Detector, 3-Way Liquid, 29 March 1967.
 3. D.A. MacLeod. Defence Research Establishment Ottawa Technical Note No. 80-3 (1980).

- 
5. R.H. Perry and C.H. Chilton. Chemical Engineers' Handbook, 5th Ed., McGraw-Hill Book Company, New York, 1973.
 6. C. Orr, Jr. and J.M. Dallavale. Fine Particle Measurement. The MacMillan Company, New York, 1959.

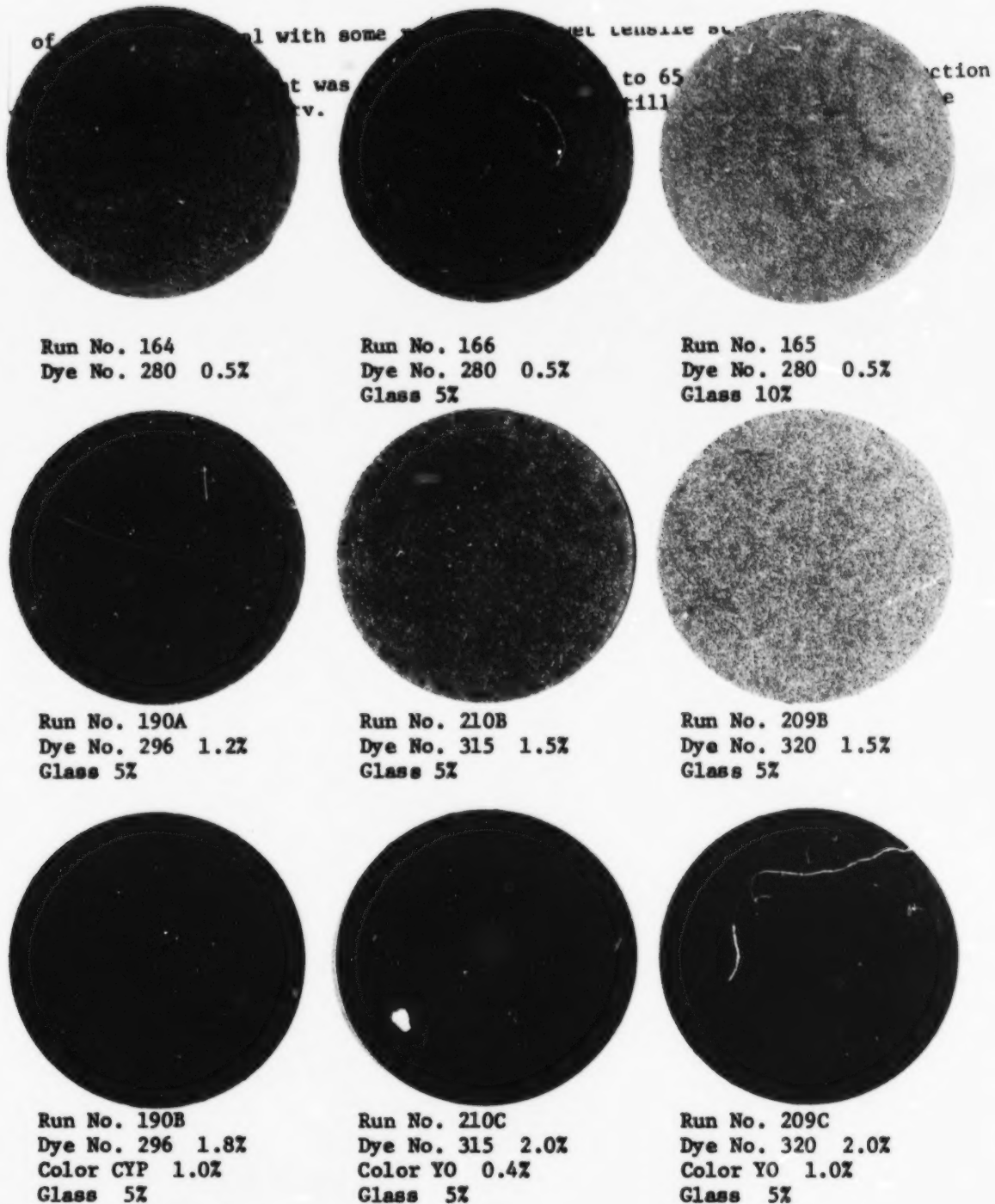
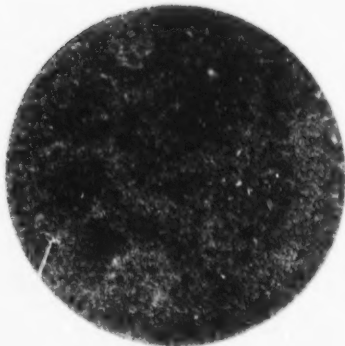
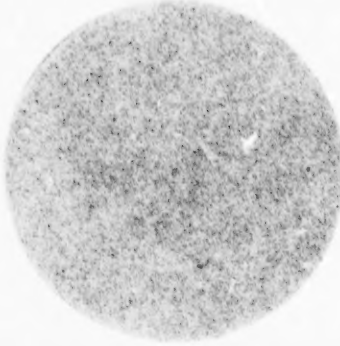


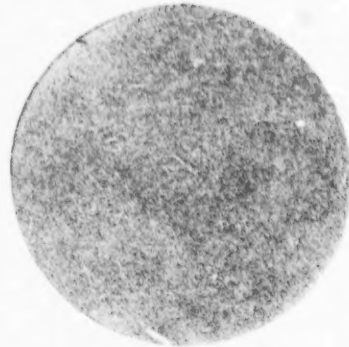
Figure 1. Samples of detector paper made with Orasol Navy Blue 2RB.



Run No. 220B
Dye No. 361 1.5%
Glass 5%



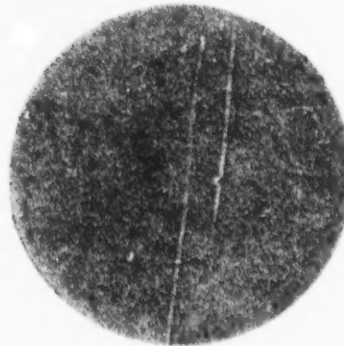
Run No. 240G1
Dye No. 361 1.00%
Glass 5%



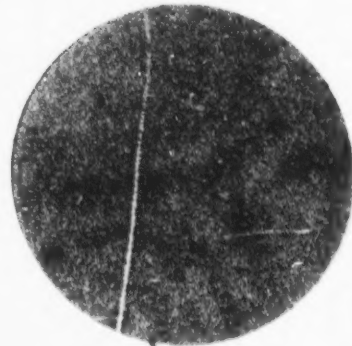
Run No. 240S1
Dye No. 361 1.00%



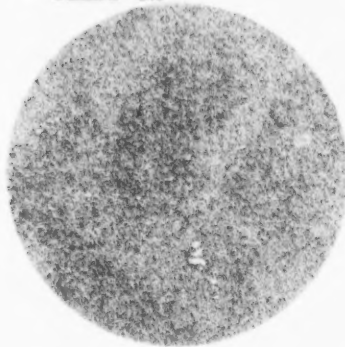
Run No. 220C
Dye No. 361 2%
Color YO 0.4%
Glass 5%



Run No. 240G2
Dye No. 361 1.33%
Color YO 0.4%
Glass 5%



Run No. 240S2
Dye No. 361 1.33%
Color YO 0.4%



Run No. 249
Dye No. 441 1.25%



Run No. 240G3
Dye No. 361 1.78%
Color YO 1.0%
Glass 5%



Run No. 240S3
Dye No. 361 1.78%
Color YO 1.0%

Figure 1 (continued). Samples of detector paper made with Orasol Navy Blue 2RB.

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PREPARATION OF DETECTOR PAPER CONTAINING ORASOL NAVY BLUE 2RB (U)

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Orosol Navy Blue 2RB was selected as a dyestuff to be used in paper for detecting propylene glycol, a possible ingredient of liquids for chemical warfare training. Dyestuff as received from the manufacturer contained a large proportion of particles that were too fine to be used in making paper. These fines were successfully removed by settling or were agglomerated by spray-drying. For propylene glycol detection, the base paper should be prepared without internal sizing but sized papers were also prepared for possible use with other liquids. Paper basis weight was reduced about 20% from the usual weight for Canadian detector papers without any decrease in performance except in wet strength of unsized paper. The effects of glass fiber, titanium dioxide pigment and background color were investigated.

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